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1.—SOME WESTERN AUSTRALIAN LAMPROPHYRES.

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INTRODUCTION.

Very few occurrences of rocks of the lamprophyre family have yet been discovered in Western Australia and no detailed descriptions of the geology or field occurrence of any members of this family can be found in local geological literature. Petrographical details of one Western Australian lamprophyre only have so far been published. In recent years, however, quite a number of lamprophyres from scattered localities have come to the writer's notice and as a result he has been encouraged to compile the following petrographical notes upon the hitherto neglected Western Australian occurrences of some members of this interesting family of rocks.

The lamprophyres constitute a rather peculiar group of igneous rocks which occur most typically as dykes or other small intrusions (1). Because of their somewhat exceptional structure and composition members of this group do not fall readily into many accepted schemes of rock classification. Chemically the common types are characterised by medium to low silica content, a relative abundance of alkalies in the form of felspars and a relatively high content of ferromagnesian silicates. They are invariably fine-grained rocks, nearly always holocrystalline and may or may not be porphyritic in texture.

The lamprophyres are characteristically rich in brown mica, but in some varieties the place of biotite is largely taken by hornblende and/or augite, and consequently the commoner types are often distinguished as mica lamprophyres, hornblende lamprophyres or augite lamprophyres, depending on the predominant ferromagnesian mineral.

A further subdivision of the common types has been made by the distinction of the predominant felspar—orthoclase in one group and plagioclase in the other. The true nature of the felspars in these rocks is often very difficult to determine, however, owing to the abundance of secondary products or to the minute size of the individual crystals. Rosenbusch considers that the rocks of the first group, so far as composition is concerned, have affinities with syenite whilst the plagioclase lamprophyres are closely related to diorite.

A peculiar feature of the lamprophyres is that in the porphyritic members of the family, felspar seldom occurs as phenocrysts but only in the groundmass. The porphyritic character is invariably produced by two generations of the ferromognesian constituents which both in phenocrysts and groundmass have a distinct tendency to idiomorphism.

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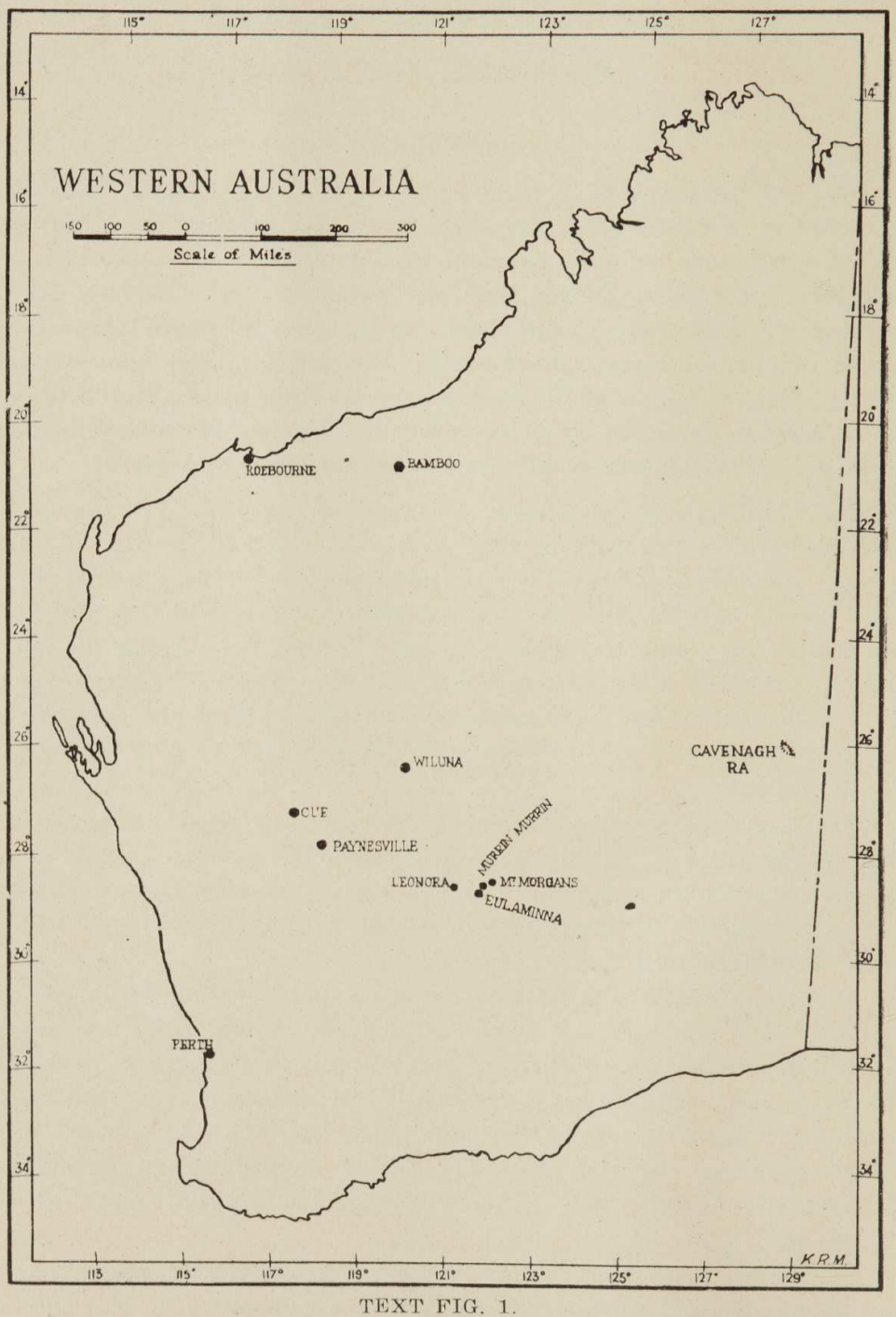
These and other typical features are to be noted amongst the 36 specimens of Western Australian lamprophyres examined and described in this paper. They come from a number of scattered centres—from the North-West at Bamboo Creek and Roebourne in the Pilbara District; and from numerous districts in the Central Goldfields, viz., Wiluna, East Murchison Goldfield; Cue and Paynesville, Murchison Goldfield; Mt. Fouracre and Mt. Newman near Doyle's Well, Leonora district, Mt. Morgans district and Eulaminna-Murrin Murrin district, Mt. Margaret Goldfield. The principal centres are illustrated in the locality map (Text fig. 1).



TEXT FIG. 1.

Showing principal reference localities of lamprophyre occurrences in Western Australia.

Such information as could be gleaned regarding the field occurrences of these specimens indicates that to a large extent the rocks had been recognised in the field as dykes or similar small intrusive bodies. In most cases the rocks intruded appear to be representatives of the Older Pre-Cambrian

(Archaeozoic) of this State. At Wiluna, Cue and Mt. Morgans, and in the Eulaminna-Murrin Murrin district the lamprophyres are believed to intersect the auriferous greenstones or lode formations of the auriferous Older Greenstone Series. Here they are definitely post folding, and probably post-gold, and in all probability are Post-Granite in age. No field evidence has so far been found to indicate whether or not any of these lamprophyre intrusions were younger than Pre-Cambrian in age. To the writer's knowledge there is no record of lamprophyre dykes intruding the Proterozoic Nullagine Formation in the North-West of this State.

PREVIOUS LITERATURE.

There are available very few published records of the occurrence of rocks with lamprophyric affinities in Western Australia either amongst petrological literature or in accounts of the general geology of the State. No published descriptions of any field occurrences can be found.

In 1909 Simpson and Glauert in a description of the crystalline rocks of the Ravensthorpe District (2, pp. 26-7) under the heading "Rocks of Intermediate Basicity" described two groups of dyke rocks which they provisionally classed as "camptonites" and "kersantites," respectively. A careful re-examination of specimens so classified (2, pp. 42-3) reveals that none show many of the characters of the true lamprophyres as outtonites," characterised by the presence of abundant amphibole (usually green hornblende or pale tremolite-actinolite) are rocks which according to modern nomenclature would be classed as epidiorites, several types of felspathic amphibolite and amphibolite schist, actinolite schist and a biotite-hornblendite. These rocks have probably been derived mainly from basic igneous types such as dolerites, basalts or basic andesites. The "kersantites" are characterised by the presence of essential brown biotite with frequent granoblastic gneissic structures and include such types as biotite amphibolite, biotite-hornblende granulite, biotite-tremolite schists, biotitic gneisses and what appears to be a magnetite-biotite hornfels. Some of these types probably represent the metamorphosed products of igneous, and others of sedimentary rocks. Montgomery in 1910 (3), in reporting on progress of mining in the Phillips River Goldfield, followed Simpson and Glauert's classification of these rocks.

The first authoritative account of a lamprophyre from Western Australia was given by J. A. Thomson in 1911 (4, pp. 300-301) when he described an "augite-hornblende lamprophyre, probably a camptonite" from the Cavenagh Range, Eastern Division. This specimen was one of a collection made by V. Streich, a member of the Elder Scientific Exploring Expedition of 1891-1892. Cavenagh Range (approx. Lat. 26° 10′S. Long. 127° 56′E.) is approximately 64 miles west of the South Australian border (Fig. 1). According to the mapping of Talbot and Clarke (5) this range consists of a comparatvely unmetamorphosed gabbro or dolerite intrusive into granite, and classed as pre-Ordovician (probably pre-Cambrian) in age.

Thomson's rock was described as dark grey, finely crystalline porphyritic, with phenocrysts of titaniferous augite and larger carbonate-chlorite pseudomorphs after an earlier mineral, olivine. The groundmass consisted of brown green hornblende prisms often with fibrous borders and kernels of augite, felspar, probably albite, in short laths or radially grouped forms, scattered nests of epidote associated with chloritised hornblende and carbon-

ates, plentifully scattered magnetite granules and accessory sphene. Thomson recorded his belief that this was "the first rock of this class so far found in Western Australia," and in a footnote remarked that "the rocks described as camptonites by Simpson and Glauert .. appear to the writer to be really contact-altered amphibolites." (4, 301.) Thomson could give no details of the field occurrence of his rock.

In 1925 E. de C. Clarke, in his bulletin on the field geology and broader mining features of the Leonora-Duketon district, Mt. Margaret Goldfield, referred to later basic dykes intrusive into both greenstone and granite and recorded that "these dykes are unaffected by dynamic metamorphism" in which lies their fundamental difference from the older though often somewhat similar looking (auriferous) greenstones (6, p. 37). In an appended classified list of specimens of these later basic dykes examined by the Petrologist (R. A. Farquharson) (6, p. 58) are included four rocks identified as lamprophyric in character—two (1/2190, 1/2192)* being determined as "very felspathic and acicular epidiorites, of camptonitic composition and structure," one camptonite (1/2211) and one "mica-lamprophyre but near vogesite" (1/2248). No further petrographic details of these rocks have been published. These rocks will be further described when the lamprophyres from the Mt. Margaret Goldfield are dealt with in the following section.

Detailed geological surveys of the Eulaminna-Murrin Murrin district in 1940-41 by R. A. Hobson have revealed that lamphrophyre dykes are relatively abundant in this region, and although no details of their occurrence have yet been published they are included in a tabular classification of rock types from the area published in a summary progress report in 1940 (7).

DESCRIPTION OF ROCKS.

In order to facilitate description of the different rocks examined and to submit such notes of their field occurrence as are available in as systematic a manner as possible, they have been arranged according to the locality of their occurrence in the State, going from north to south. As will be seen, in many cases no details of the occurrence of individual specimens is available.

NORTH-WEST DIVISION.

Bamboo Creek, Roebourne.

Two specimens having affinities with the lamprophyres both in mineral composition and microstructure come from the Pilbara District of the North-West. They were both collected by T. Blatchford during investigations in the district in 1912 (8). The first (12545) is registered as "dyke, Bamboo Creek," and no other details of field occurrence are available. According to Maitland (9) Bamboo Creek mining centre consists essentially of steep dipping Archaean (greenstone) schists and laminated chert intruded by granite, faulted and overlain to the east by gently dipping sedimentary rocks and interbedded felsitic lavas, presumably of Nullagine age.

In hand specimen this is a very dense fine-grained grey coloured rock in which can be distinguished occasional scattered clear felspar phenocrysts up to 2 mm. in diameter.

*All following numbers except those preceded by the letter U refer to register or field numbers in the Geological Survey Rock Collection. Those preceded by U come from the General Rock Collection of the Department of Geology, University of W.A.

In thin slice this is found to consist largely of a fine, even-grained aggregate of interlocking felspar laths and interstitial shredded, chlorite pseudomorphs after biotite, enclosing occasional phenocrysts of cloudy altered felspar (probably acid plagioclase), and smaller shredded plates of bleached biotite. Secondary epidote in granules replacing felspar, associated with the chlorite and also in scattered groups of subhedral plates is common. Extinction angles indicate that the felspar laths of the groundmass are largely basic oligoclase (Ab_{73}) though some of the more cloudy laths may be orthoclase (parallel extinction in many sections and refractive index less than balsam). Sphene is a common accessory and several patches of interstitial quartz occur. This slice includes an irregular patch of introduced sulphide (pyrite) surrounded by epidote crystals.

Although it is not typical of the family this rock is in all probability an altered form of original mica lamprophyre—near kersantite.

The second specimen (12579) comes from the old Fortune Copper Mine, Glenroebourne in the Roebourne district. According to Woodward (10) the fundamental rocks in this district consist mainly of ancient basic igneous types—dolerites and gabbros with intrusive hornblende granite. Blatchford marked this specimen as a "dyke rock," whilst another specimen marked "country rock" from the same locality proves to be a uralitised quartz gabbro. (12579) is a fine-grained reddish brown coloured rock through which are scattered plates of dark green mica up to about 3 mm. diameter, giving it a very speckled appearance. The mica has a tendency to orientation in one plane, giving the appearance of a rude schistosity.

In thin slice the mica phenocrysts are seen to be green pleochroic biotite with Z = deep green, Y = deep yellowish green, X = pale greenish yellow: $Z < Y > X$. They often enclose granules of iron ore, zircons with pleochroic haloes, and contain interlaced needles of rutile. Other phenocrysts consist of a few irregular pale yellowish green chloritic areas, whose centres are largely replaced by carbonates—probably representing original augite or possibly olivine.

The ground mass consists of an interlocking aggregate of felspar laths —twinned laths are albite (Ab_{92}), though some untwinned material may be orthoclase—shredded green biotite, and abundant granular carbonate plentifully sprinkled with octahedra of magnetite. In addition scattered through the ground are fairly numerous irregular areas up to 1 mm. diameter filled with clear quartz or calcite, or both, which possibly represent amygdales.

This is a typical mica lamprophyre which, judging from the abundance of plagioclase felspar, may be classed as a kersantite.

THE CENTRAL GOLDFIELDS.

East Murchison Goldfield—Wiluna.

During the University vacations of 1935-36 the writer, while employed on the Wiluna Gold Mine collected specimens of a fresh, dark, brown-looking dyke rock from the south side of the plat at the main shaft, 1,000 ft level, which he later determined as a camptonite. The country rocks of the Wiluna Gold Mine consist of a series of vertically dipping amphibolite and chlorite schists all more or less carbonated, representing original interbedded basic flows, including beds of pillow lavas of Pre-Cambrian (Older Greenstone)

age. These rocks have been intruded by dykes or sills of felsite, sheared along major zones with the production of graphitic shear walls, and then largely replaced by carbonates along the shear zones to form calc schists. Sulphides—arsenopyrite, pyrite, stibnite, etc., have been introduced together with gold, with the carbonating solutions. Post-gold dykes of black basaltic dolerite are known to intersect the country in the Wiluna Gold Mine.

The writer has no direct evidence that the rock (U15295, U18853) to be described below forms portion of a post-gold dyke but the absence of any signs of carbonatisation within it and its unaltered appearance amongst the carbonated, chloritised and uralitised country rocks indicate a younger intrusion. No evidence is available as to the relative ages of this rock and the basaltic dolerite.

This rock (U15295) is dense fine-grained, dark red brown in colour with irregular greenish areas and is sprinkled with glistening tiny black needles up to 2 mm. long. In another specimen (U18853) the needles are far less distinct and the greenish areas are more prominent. The rock is sprinkled with rare crystals of pyrite.

The typical form and mineral composition of (U15295) is illustrated in Text Fig. 2A. Euhedral needles of hornblende are scattered in random orientation, together with a few chloritised, epidotised, carbonated remnants of colourless augite plates, through a very fine-grained groundmass of minute interlocking laths of plagioclase sprinkled with granules of magnetite, occasional cloudy carbonate areas, a little granular epidote, and scattered crystals of pyrite.

The hornblende crystals are distinctly pleochroic, with X = yellow, Y = yellow brown, Z = greenish brown; absorption Z = Y > X; Y = b, $Z \wedge c = 20°$; (—), $2V$ large (about 85°). This is a true hornblende. Basal sections show strongly developed (110) faces often to the exclusion of (010). Twins on (100) are common with occasional central darker zones. The areas of original pyroxene are all more or less completely replaced by pseudomorphs of pale green chlorite often with yellow epidote or granular carbonate.

The felspar laths frequently show albite twinning with sections cut normal to the twin plane having extinction angles up to 12°. Refractive index is either less than or about equal to canada balsam thus indicating albite (Ab_{90}). Under high powers the groundmass is seen to be crowded with minute hornblende and probably some apatite needles, thus making an estimate of the approximate mineral composition of the rock extremely difficult. Approximate figures based on measurements under low powers are:—Felspar, 55-60%; hornblende, 30-35%; epidote and chlorite, pseudomorphs 6%; pyrite 2%; other accessories (magnetite, carbonates, apatite, etc.) 2%. This rock is an excellent example of a hornblende lamprophyre-variety camptonite.

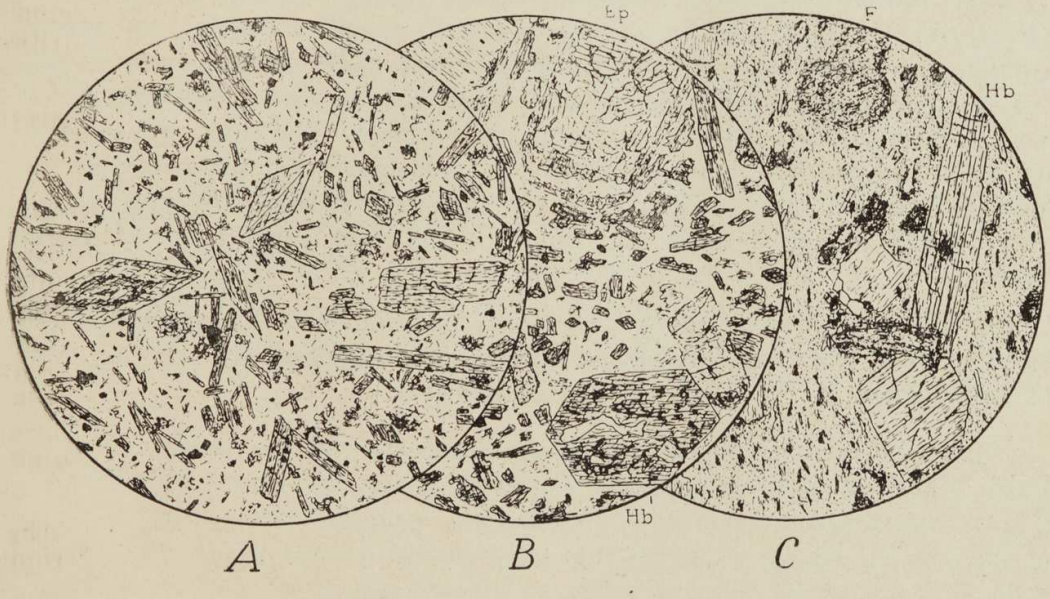
(U18853) is a coarser-grained specimen which contains phenocrystal plates of euhedral chloritised biotite, whilst the hornblende needles are largely replaced by shredded chlorite and magnetite granules. The felspar laths are frequently grouped in radiating aggregates, whilst apatite in short stumpy crystals is an abundant constituent. Pyrite is plentifully sprinkled throughout, granular carbonates are common and a little vein quartz can be seen.

(a) *Cue.* Murchison Goldfield.

Specimens of a lamprophyric dyke rock were recognised and collected by Dr. R. T. Prider from the core of a bore drilled in 1935 by Anglo-Australian Gold Development Company for Day Dawn Gold Mines on the old Lady Forrest Lease, about a mile south-west of Cue townsite. The country here consists of epidiorite-amphibolite (Older Greenstone Series) intruded by gabbros, and granite and porphyry dykes (11).

Specimens examined were taken from Bore No. 2 at depths of 1,012 ft. (U13437), 1,013 ft. (U12436), 1,014 ft. (U13438) and at 1,014 ft. 3 inches (12437). The last specimen showed the contact between the lamprophyre dyke and the adjoining country rock. From information kindly supplied by Dr. Prider it would appear that the total length of dyke contained in this bore core was about 2 ft. 7 inches. The angle of intersection at the lower contact was approximately 35°, so that the dyke was probably about 18 inches wide. Dr. Prider also reported that the end of Bore No. 2 at 1,021 ft. 2 in. penetrated 2 inches into a second lamprophyre dyke. No specimen of this occurrence was available, however.

All specimens were greenish grey coloured, medium-fine grained and porphyritic with distinct whitish phenocrystal areas (?felspar) up to 2·5 mm. diameter.



TEXT FIG. 2.—Hornblende Camptonites, Murchison.

A. (U15295). From 1,000 ft. level Main Plat, Wiluna G.M., showing euhedral hornblende phenocrysts in a fine-grained albite-hornblende groundmass with scattered magnetite and pyrite grains (black). A few epidote-chlorite pseudomorphs after pyroxene occur in other parts of the slice.

B. (U13437). From No. 2 Bore, Daydawn G.M., Cue, at bore depth 1,012 ft., showing euhedral hornblende phenocryst (Hb) enclosing felspar and a nest of epidote (Ep) pseudomorphous after phenocrystal felspar. Epidote also builds smaller plates and hornblende forms a second generation of small needles. The clear plate in the top left-hand corner is chlorite.

C. (U12437). From the same dyke, No. 2 Bore at 1,014 ft. 3 in. at its chilled contact with epidiorite wall rock. Shows clear phenocrystal hornblende (Hb) and cloudy saussuritised felspar (F) in an extremely fine-grained felted groundmass.

Under the microscope (U13437) was seen to be the most coarsely grained, the others showing a gradational decrease in grain size of the groundmass as the contact is approached. A slice cut from (U12437) right at the contact shows the groundmass as a cryptocrystalline aggregate with a distinct fluxional arrangement of the minerals. The coarse specimen, and this contact specimen are illustrated in Text fig. 2 B and C.

The phenocrystal minerals consist of euhedral greenish yellow to brown hornblende in tabular crystals similar to that of the Wiluna rock, clear plates or cloudy granular aggregates of epidote or zoisite pseudomorphous after phenocrystal felspar, and here and there associated with colourless uralite or chlorite in pseudomorphs after pyroxene. The groundmass consists principally of prisms of hornblende and cloudy granular epidote or zoisite and euhedral laths of clear colourless felspar—twinned individuals being albite—oligoclase (Ab_{88-90})—with possibly some orthoclase. The ground is sprinkled with rare magnetite granules and a little pyrite. One round grain of resorbed quartz with a reaction border of amphibole cystallites was noticed in (U13437). As the border of the dyke is approached the groundmass generation of hornblende becomes reduced to an irresolvable felted aggregate of minute euhedral needles, whilst the phenocrystal felspar instead of being replaced by clear epidote consists of a dark cloudy aggregate of saussurite (see Text fig. 2C).

This is a typical narrow dyke rock—camptonite showing a chilled margin at its contact with the invaded uralitic epidiorite country.

(b) *Paynesville.*

This specimen (1/3730) was collected by A. G. D. Esson in November, 1924, during the course of his survey of the Paynesville district, the results of which are contained in an unpublished report (12). The specimen came from the flats about two miles west of East Mt. Magnet Trig., which lies some 10 miles south-south-west of Paynesville centre. The rocks of this area have been mapped by Esson as greenstone (epidiorite) presumably of the Older Greenstone Series, which has been invaded by bodies of quartz porphyry, dykes of keratophyre and quartz veins, and capped by ironstone gravel.

(1/3730) is a fresh dark green-grey medium to fine-grained rock, glistening with plates of grey-black ferromagnesian minerals ranging from less than 0.2 mm. up to about 1.4 mm. in diameter.

Under the microscope the ferromagnesians are seen to consist of a few tabular plates of colourless augite (optically + ve, 2V about 70°, $Z \wedge c = 44°$) averaging about 0.8 mm. x 0.4 mm., but ranging up to 2 mm. x 1 mm. and showing all stages of alterations to greenish uralitic amphibole; several fairly large scattered laths of green to yellow pleochroic biotite up to 1.5 mm. long and numerous smaller plates rather shredded and clouded by granules of separated iron oxide; very abundant needles and laths of green hornblende from 0.1 up to 1 mm. long, showing various degrees of alteration to chlorite and epidote and with inclusions of ore rimmed by iron oxide; and a few scattered granular aggregates of epidote. The original euhedral form of the hornblende is often masked by the secondary alteration products.

The ferromagnesians are enclosed in a clear groundmass of cryptocrystalline felspar often in minute semi-radiating aggregates whose nature is not determinable, though the refractive index (about that of balsam) suggests a soda-rich plagioclase. The felspars are here and there clouded by granular carbonate. The groundmass is sprinkled with granules of magnetite, abundant needles and well formed tabular crystals of apatite and occasional accessory grains of sphene.

This is a typical hornblende lamprophyre, probably camptonite.

Mt. Margaret Goldfield.

This goldfield has so far yielded by far the greatest number of specimens of lamprophyres. These have come from three separate districts—Leonora, Mt. Morgans and Eulaminna-Murrin Murrin. The bulk of the known occurrences are in the vicinity of Murrin Murrin, and most of the specimens were collected by R. A. Hobson during the course of the re-survey of portion of the Mt. Margaret Goldfield, 1940 and 1941. The lamprophyres have been recognised as some of the youngest intrusives in this district and post folding in age, though Hobson still considers them to belong to the Pre-Cambrian (7).

(a) *Leonora District.*

Two specimens (1/2190, 1/2192) collected by Clarke from Mt. Fouracre near Doyle's Well, and from the Victory lease west of Mt. Newman, respectively, were classed by Farquharson as camptonitic epidiorites (6, p. 58) as mentioned above.

These are both grey coloured, medium-fine, even-grained rocks. (1/2190) shows cataclastic structure under the microscope, consisting of needle tufts of pale green hornblende with a little scaly brown biotite intergrown with even-granular tabular plates of basic oligoclase showing peripheral granulation, and some interstitial quartz. Accessory minerals are sphene, with minor apatite and magnetite. (1/2192) is slightly coarser-grained with the amphibole tabular, idiomorphic and the felspar shows little signs of cataclasis. Interstitial minerals include quartz and chlorite.

These two rocks, though having the approximate mineral composition of camptonite have the structure of slightly crushed fine-grained diorite.

Two other specimens from the Leonora district, however, also collected by Clarke in 1918 show close affinities with the mica lamprophyres. These are (1/2006) from the "Blue Spec" workings and (1/2015) from the Mt. George group (east of the old Aukland Gold Mine), some nine miles north of Leonora.

The first is a rather weathered specimen—grey-white coloured, fine even-grained, and consists of shredded aggregates of pale brown biotite enclosed in a groundmass of radiating brushes of felspar (apparently albite), with a few interstitial grains of quartz. The felspar areas are crowded with minute interlaced colourless needles of apatite, visible only under high powers. (1/2015) is a dark coloured medium-fine-grained rock sprinkled with glistening plates of brown biotite up to 1.5 mm. diameter. In thin slice this was seen to contain two generations of biotite—in phenocrystal plates strongly pleochroic with X = yellowish brown, Y = greenish brown and Z = very dark brown, $X < Y < Z$, and with resorbed borders; and in small very abundant euhedra laths intergrown with the groundmass felspar (albite) which is frequently in radiating groups of laths. Accessories are a few grains of quartz, a little granular iron ore and scattered pyrite. This rock is a normal mica lamprophyre (kersantite).

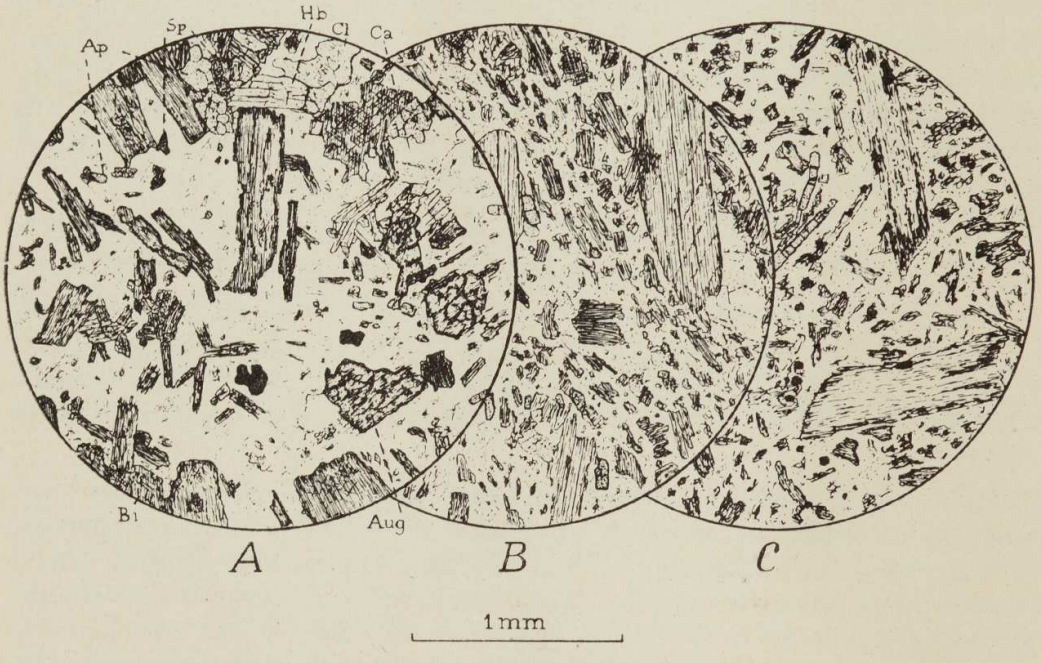
(b) *Mt. Morgans District.*

Several specimens of the so called "mica bars" from the late Westralia-Mt. Morgans Gold Mine at Mt. Morgans have been collected from time to time. These "mica bars" are said to cut through the lode. Specimen (5684) was obtained by C. F. V. Jackson in 1904, (1/2248) by Clarke in the course of the Leonora-Duketon Survey (6, p.58) and (L315) was collected by the

present writer in 1938. The last specimen came from the main drive of the 200 ft. level, about 80 feet north of the main shaft. No further details of the exact locations of the other specimens are available.

All three rocks are mica lamprophyres which show traces of a rude schistosity due to a slight orientation of the biotite phenocrysts. Specimen (L315) is considerably bleached and oxidised but (5684) is a fresh dark grey rock sprinkled with shining black biotite plates up to 2.5 mm. in diameter, and scattered crystals of pyrite. In thin slice the rough orientation of the biotite phenocrysts is noticeable, see Fig. 3 B. These are intensely pleochroic X = pale yellow, Y = deep brown, Z = deep red brown. Moulded upon the phenocrysts or associated with the scaly biotite of the groundmass is calcite in clear plates or granular aggregates. The felspar of the groundmass is mainly in cryptocrystalline aggregates too small for identification but there are areas of larger radiating aggregates of plagioclase (albite) showing lamellar twinning with extinction angles up to 10°.

Specimen (1/2248) is distinctly coarser-grained than the last specimen, with the glistening black phenocrysts of biotite up to 3.5 mm. The grey granular groundmass is relieved with crystals of pink felspar.



TEXT FIG. 3.—Mica Lamprophyres, Mt. Margaret Goldfield.

A. (1/2248). Augite minette from late Westralia-Mt. Morgans G.M., Mt. Morgans, showing biotite flakes with sagenite (Bi), remnants of augite (Aug), a little shredded chlorite (Cl) and a hornblende plate (Hb) set in a clear felspathic groundmass (predominantly orthoclase) with some calcite (Ca). The black opaque grain is pyrite and other accessories include apatite (Ap) and sphene (Sp).

B. (5684). From the same locality, showing biotite flakes in two generations with granular calcite in a cryptocrystalline felspar ground. Probably kersantite.

C. (L632A). Kersantite from a shaft dump about half-mile south of Murrin Murrin Siding. Shows phenocrysts of bleached chloritic biotite in a groundmass of clear albite-oligoclase laths studded with biotite shreds, magnetite, pyrite and carbonates, and broken needles of apatite in the centre of the field.

The microscopic appearance of this rock is illustrated in Text fig. 3A Chief ferromagnesian is biotite—mostly green-yellow with X = greenish yellow, Y = greenish-brown, Z = deep brownish-green, though some of the larger phenocrysts have cores of yellow-brown colour similar to the biotite in (5684). Some plates show interlacing sagenitic rutile due to the separation out of their titania content, and most have darker resorption borders.

Pale greenish augite having original euhedral forms but now partially replaced by fibrous green amphibole is a lesser but nevertheless abundant constituent, and a few separate prisms of euhedral green chloritic hornblende can also be seen. These minerals are enclosed in a ground of fairly coarse clear felspar plates which show simple twinning and are optically—ve with refractive indices distinctly less than balsam, hence are orthoclase. Apatite in short stumpy crystals and irregular granules, and small diamond-shaped crystals of sphene are abundant accessories. Small quantities of carbonate (calcite) in anhedral grains often enclosing granular apatite are scattered throughout the slice and clear twinned oligoclase occurring in a few rare small grains interstitial between orthoclase or biotite plates or associated with carbonates, is obviously one of the last formed minerals.

This rock was classed by Farquharson as a "mica lamprophyre near vogesite" (6, p. 58) but taking into account the predominance of mica amongst the ferromagnesians it may be preferable to call it an augite-minette.

Specimen (1/2082) collected by Clarke and said to come from 7½ miles north-east of Mt. McKenzie, Mt. Morgans, is a dark greenish schistose chloritic rock, which is reddish coloured on weathered surfaces. In thin slice it is revealed as a chloritised hornblende lamprophyre which has undergone dynamic stress. Ragged oriented shreds of chlorite pseudomorphous after hornblende are scattered through a ground of granulated felspar—probably both orthoclase and sodic plagioclase. Accessory apatite and pyrite are common and magnetite and carbonate granules are also present.

(c) *Eulaminna-Murrin Murrin District.*

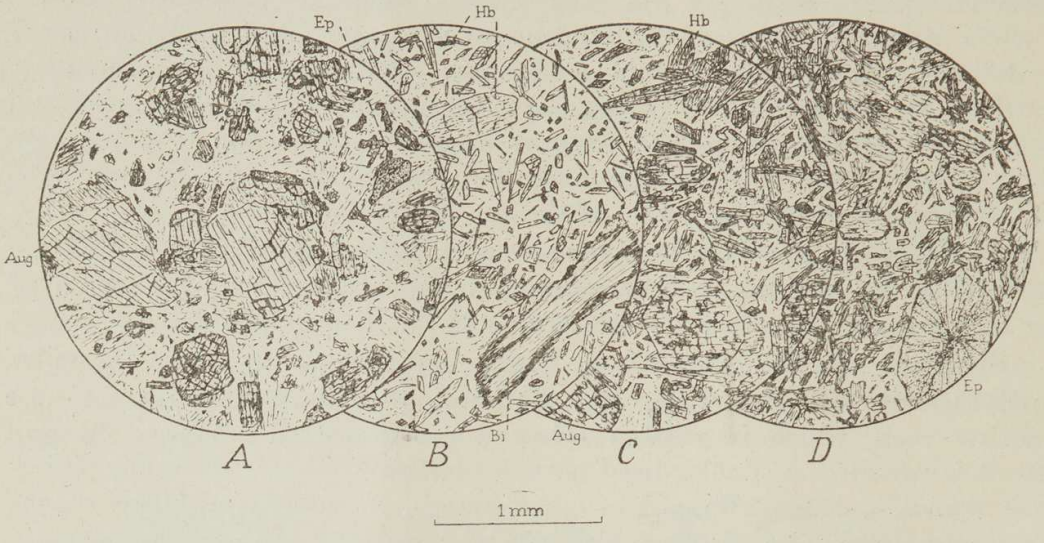
Of the 19 specimens of lamprophyres so far collected from this district, 11 can be classed as hornblende or augite lamprophyres and the remainder mica lamprophyres.

Specimens of the former group include (1/2211) collected by Clarke from 140 chains north of Eulaminna, marked "dyke in greenstone" (6, p.58); (L808) from 2½ miles due south of Eulaminna, (L635), (L644), (L725), (L728), (L731) from within a radius of two miles of Murrin Murrin either to the south or east, (L724) from 3½ miles south-east of Murrin Murrin Siding, and (L787), (L788) from the vicinity of the Pearl Shell leases some 3½-4 miles north-west of Murrin Murrin, all collected by R. A. Hobson in 1940; and (L299) collected by the present writer from a narrow dyke cutting through coarse porphyritic gabbro at a point half a mile due north of Murrin Murrin Siding.

Of Hobson's collection all specimens except (L635), (L724), which came from mine dumps and (L808), were broken from the outcrops of small dykes intrusive into bodies of amphibolite, basic lavas or dolerite (considered to be representative of the Older Greenstones) which form portion of the country rocks of the district.

(1/2211) is a typical hornblende lamprophyre—fresh medium grained, grey coloured, sprinkled with abundant black amphibole needles and less frequent tabular greenish crystals of pyroxene. The amphibole is euhedral brown hornblende similar in optical character to that in the Wiluna camptonite described above. The needles range from less than 0.2 mm. up to 2 mm. in length. Euhedral colourless augite occurs in short tabular plates in varying degrees of alteration to fibrous chlorite, individual crystals being developed up to 1 mm. in diameter. The predominant felspar is slightly

cloudy, rarely twinned albite-oligoclase (Ab_{86}-Ab_{90}) in well formed laths whilst minor quantities of orthoclase showing carlsbad twins, also occur. Accessory apatite is present in minute colourless needles whilst iron oxide, chlorite, etc., are common secondary products. This rock is a normal camptonite.



TEXT FIG. 4.—Augite and Hornblende Lamprophyres, Mt. Margaret Goldfield.

A. (L644). Augite camptonite from a dyke 70 chains south of Murrin Murrin Siding. Contains clear phenocrystal augite (Aug) showing marginal alterations to amphibole and chlorite and yellow epidote grains (Ep.) in a groundmass of subradiating plagioclase laths with interstitial chlorite.

B. (L635). Hornblende camptonite from a shaft dump, Murrin Murrin, showing a phenocryst of bleached brown biotite (Bi) and two generations of hornblende (Hb). Phenocrystal augite and some epidote occur in other portions of this slice.

C. (L808). Augite-hornblende camptonite from a dyke 2½ miles south of Eulaminna, showing euhedral augite (Aug) phenocrysts and smaller laths and needles of hornblende (Hb). The felspar of the groundmass is albite.

D. (L299). Hornblende camptonite from a dyke half-mile north of Murrin Murrin, showing fibrous hornblende in clustered phenocrysts pseudomorphous after augite, and a radiating aggregate of epidote (Ep), set in a groundmass consisting of shredded green hornblende and clear sodic plagioclase laths.

Specimens (L644), (L635), (L808) and (L299) are illustrated in Fig. 4 A-D. The first is a greyish green medium-fine-grained porphyritic rock with phenocrysts of usually fresh, clear, colourless augite plates which show occasional slight alteration, both marginal and along fractures, to pale green chlorite and uralite. This augite is non-pleochroic, optically positive with a moderately large optic axial angle (about 70°); $Z \wedge c = 44\text{-}45°$. Prismatic sections have one well developed cleavage parallel to c, whilst parallel extinction on basal sections indicate that (100) and (010) are the predominate cleavages. The only other ferromagnesian mineral present in any quantity is epidote in anhedral bright greenish yellow granules (pistachite). The felspar (albite) occurs in the groundmass in radially grouped aggregates of long laths with occasional small interstitial grains of quartz. Small areas of carbonates are scattered through the ground. Apatite in short needles is an important accessory. This is an augite camptonite notable for the entire absence of amphibole, except perhaps for some secondary needles associated with the chlorite.

(L635) is a dark grey rock slightly coarser-grained than (L644). It contains phenocrysts of rather bleached-looking brown biotite showing marginal resorption and alteration to green chlorite with the separation of iron oxides, fresh green-brown hornblende, and remnants of colourless augite in

process of alteration to green scaly chlorite and tremolite. Euhedral hornblende also occurs in a second generation of small needles scattered through a ground of sodic plagioclase with a little orthoclase, and scattered areas of secondary carbonate. This can be classed as a hornblende camptonite with minor augite and biotite.

(L808) is dark green, dense and finer-grained than the previous specimens and contains euhedral phenocrystal augite occasionally showing resorption borders, set in a groundmass of euhedral brown hornblende and cloudy lath-like albite. Here and there are scattered clear rounded areas consisting largely of radiating plagioclase occasionally enclosing grains of epidote and pyrite. This rock is an augite-bearing hornbende camptonite.

(L299), a dark green fine-grained rock contains hornblende in two generations—phenocrystal green, rather fibrous plates often pseudomorphing pyroxene, and aggregates of shredded thin laths. Yellow epidote of phenocrystal size is the only other ferromagnesian, and this also appears to be a replacement mineral. The felspars in the groundmass are sodic plagioclase, often in radiating sheaves, with here and there small clear rounded areas filled with a partially resorbed albite plate, or with aggregates of slightly coarser crystals. This is a hornblende camptonite.

Of the remaining specimens in this group (L725), (L728) and (L731) are very fine-grained greenish-black hornblende camptonites. The first contains phenocrystal chloritised augites up to 1 mm. diameter, carbonate and quartz in an acicular hornblende-plagioclase groundmass, whilst in (L728) scattered small rounded areas of green serpentine with centres of granular epidote suggest the remains of original early-formed olivine, enclosed by sheaves of interlacing brown green hornblende needles. The predominant felspar is oligoclase. (L731) shows a distinct orientation (flow structure) of the short idiomorphic felspar laths in a groundmass which also contains shredded green chlorite replacements of hornblende, abundant carbonate granules and a little interstitial quartz. Judging from the predominant +ve optical character the bulk of the felspar is albite, though some orthoclase is probably present. The groundmass encloses rare areas of granular epidote and chlorite probably pseudomorphous after a pyroxene.

Specimens (L724), (L788) and (L787) are all distinctly porphyritic, the first two being greenish and the last brownish coloured. (L788) and (L787) have idiomorphic phenocrysts of brown hornblende up to 12 mm. long. In (L724) the principal phenocrysts are augite plates up to 2 mm. diameter usually completely uralitised, and scattered roundish areas up to 0.4 mm. diameter of green serpentine rimmed with magnetite, marking original olivines. Groundmass contains greenish-brown biotite, green chlorite and amphibole shreds (largely from augite) with plagioclase in blurred outlines. Magnetite granules are also abundant. This is an altered augite camptonite which originally contained a considerable proportion of olivine.

(L788), (L787) are both augite-hornblende camptonites, the former containing fresh brown-yellow hornblende and chloritised, carbonated augite phenocrysts with scattered areas of quartz and carbonates in a very fine-grained groundmass. The latter consists of euhedral phenocrysts of green-brown hornblende and pale green augite with smaller yellow epidote, green chorite and rare laths of sodic oligoclase, in a ground of sheaf-like idiomorphic plagioclase and short hornblende laths with a little interstitial quartz, and accessory magnetite, apatite and pyrite.

Of the mica lamprophyres from the Eulaminna-Murrin Murrin district, specimen (1/2229) was obtained from the Main Shaft dump on the old Anaconda Copper mine at Eulaminna by Clarke in 1918 and (L332) was collected by the writer in 1938 from a narrow dyke cutting coarse porphyritic gabbro at about two and a half miles north of Murrin Murrin. The remaining six specimens (L631), (L632A), (L637), (L638), (L665) and (L669) were collected by R. A. Hobson. Of these all except the last came from the dumps of shafts on leases lying to the immediate south or south-west of Murrin Murrin Siding. (L669) came from a dyke, near (L644), intruding a small area of quartz dolerite at 70 chains due south of Murrin Murrin.

All of these rocks are greenish-grey in colour—except (L669) which is brown—and in all specimens shining flakes of mica, dark green and changing to silvery grey on weathered surfaces, up to 8 mm. in diameter are scattered through a fine-grained ground. Many specimens show a rude schistosity owing to orientation of the mica phenocrysts.

The phenocrystal mica is invariably in a very bleached condition and the original brown colour is seldom seen. It is occasionally altered to pale green chorite with a dark rim of iron oxide. This is illustrated in Fig. 3C of a typical specimen (L632A). Frequently plates sliced parallel to the base show interlaced rutile needles in typical sagenite structure. In many of the specimens the felspathic groundmass is turbid crowded with secondary products—shredded chlorite, carbonates, iron oxides—and the true nature of the felspar cannot be determined, but in (L632A), (L669) it is predominantly albite-oligoclase $Ab_{(88-90)}$. Most specimens contain little interstitial quartz in the groundmass which is usually sprinkled with magnetite grains. Epidote builds phenocrystal aggregates in (1/2229) and is a decomposition product of the mica in (L669). Apatite is a common accessory in most specimens and occurs in typical cross-fractured needles in (L632A). It is particularly abundant in (L669) and builds stumpy euhedral crystals, one of which measured 0.5 mm. long by 0.2 mm. wide.

Specimens (L631), (L637), (L638) and (L665) are in highly chloritised and carbonated condition and can only be classed as altered mica lamprophyres, but (1/2229), (L332), (L632A) and (L669) are normal kersantites.

SUMMARY.

Some 36 specimens of lamprophyres from widely scattered centres in the North West and in the Central Goldfields have been examined and described. They comprise many of the common types of mica, hornblende, and augite lamprophyres including kersantites, an augite-minette, hornblende and augite camptonites, some of which show a certain amount of secondary alteration.

Such field information as is available indicates that the lamprophyres are everywhere intrusive into the older metamorphic rocks of the Pre-Cambrian, viz., the Older Greenstone Series, but there is no evidence to show that they are anywhere contemporaneous with or younger than Nullagine (Proterozoic) Age.

The Eulaminna-Murrin Murrin district of the Mt. Margaret Goldfield has proved the most fruitful area for lamprophyre dykes so far found in this State, specimens having been collected from some 19 localities within this area.

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